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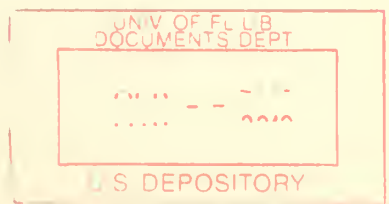
THE DECAY OF CABBAGE IN STORAGE: ITS CAUSE AND PREVENTION.

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THE DECAY OF CABBAGE IN STORAGE: ITS CAUSE AND PREVENTION.^a

INTRODUCTION.

The loss from decay of cabbage in winter storage has increased to such an extent in some districts in the past few years as frequently to make the growing of this crop an almost unprofitable industry. Of the thousands of tons stored every fall to supply the markets in the winter, from 10 to 50 per cent is lost annually from decay. Soon after the cabbage is put in the storage house many of the outer leaves of the heads turn black and become soft. In order to meet the requirements of the market it is necessary to pull off several of the outer leaves, thus reducing materially the size of the head.

Investigations into the causes of the decay of cabbage in storage and into the means of preventing it were undertaken for the purpose of determining the factors contributing to this loss and what practicable remedial measures can best be employed to reduce it to a minimum.

It was necessary to determine the extent to which bacterial organisms and leaf-blight were responsible for the trouble and how they gained access to the tissue of the cabbage. This investigation necessitated a study of the disease affecting cabbage in the fields from which storage stock was obtained and of the methods of handling the crop when being harvested and placed in storage houses.

As the development of the bacteria and the leaf-blight which are largely responsible for the decay of cabbage depends on temperature and humidity, a study was made of the construction of the houses, with a view to the control of these factors during the storage period.

These studies must be regarded as preliminary, undertaken to learn the nature and importance of the problem. The writer has observed in the fields the method of harvesting and storing cabbage during two seasons. Examinations were also made of houses where loss occurred and of those relatively free from loss. During a period of several months the range of temperature and the relative humidity in such houses were observed.

^a This paper was prepared at the request of Prof. L. C. Corbett, Horticulturist of the Bureau of Plant Industry, after a study of conditions in the State of New York. It has reference especially to the northern cabbage districts, from New York to Minnesota, where the winter storage of this crop is largely practiced. It aims merely to diagnose the situation and outline plainly needed preventives.—B. T. GALLOWAY, *Chief of Bureau.*

The conclusion has been reached that cabbage which comes to storage in good condition can be preserved if the best types of storage houses are adopted and the temperature and humidity properly regulated by careful ventilation, but this is only one phase of the storage problem. Its complete solution is not likely to be reached until the problem is taken up from the field standpoint and demonstrations made of the influence on keeping quality of methods of culture, care in handling, time elapsing between harvesting and storage, etc. The Bureau of Plant Industry has already shown the important influence of these factors on the keeping of oranges and other fruits.

That a great improvement can be made in the technique of cabbage storage is not to be doubted, but until the time arrives when funds for such work are available the suggestions in this circular may assist cabbage growers and warehousemen to reduce their losses.

FACTORS CONTRIBUTING TO DECAY.

It seems hardly necessary to emphasize the point that no diseased cabbage should go into winter storage. Diseased heads not only do not keep well, but they become the source of infection for healthy stock.

FIELD INFECTIONS.

All three of the diseases causing loss of cabbage in storage may originate in the field. Black-rot, so far as known, always results from infections in the field. An examination should be made of all cabbages before storing, and heads affected with black-rot rejected. Frequently only very slight traces are observable, and it is perhaps permissible to store such heads for short periods. Their keeping quality has, however, become impaired and they should be marketed early. Cabbage that has been frozen in the field should either be allowed to thaw and dry before going into the storage house or be rejected altogether, as frozen cabbage does not keep well.

The soft-rots are less common in the field, but when they occur are often very destructive. Special care should be taken to reject cabbages which show traces of soft-rot when brought in for storage.

Leaf-blight is quite common in some fields, but is usually confined to the outer leaves, which can be removed before storing. This disease is usually regarded as less important than the soft-rots, as its further development can be prevented by proper ventilation of the storage house.

HOUSE INFECTION.

If a house has been used for one or more seasons for storage purposes and there has been any evidence of decay, it is a good plan to disinfect the interior of the building in the fall before new stock is put in. The spores of many fungi and bacteria can retain their

vitality for a long time. If they are left in a house that has not been disinfected from one season to the next, the newly stored crop is exposed to infection whenever temperature conditions are favorable.

Spraying the walls, ceiling, and benches with about a half of 1 per cent solution of copper sulphate or the application of a whitewash alone, either of which could be applied with the usual spray pump, would be cheap and practicable. An application of either a copper solution or whitewash should be made long enough before the house is used for storage to permit the wood to dry thoroughly.

CARELESS HANDLING.

A large proportion of the decay in stored cabbage doubtless originates in bruises due to rough handling. Plant tissues are well protected against decay so long as they are uninjured, but any break in the epidermis may serve as a starting point of decay.

Whole loads of cabbage have been seen at the storage house with scarcely a head not bruised and torn from careless handling. Cabbages should be given the same attention that expert fruit packers give to apples. The heads should never be thrown into the wagon when gathering in the field or thrown from the wagon to the bin when unloading, but always passed from hand to hand.

ORGANISMS CONCERNED IN DECAY.

An examination of cabbage undergoing decay in storage shows that three kinds of organisms — black-rot, soft-rot, and leaf-blight — are principally concerned in producing the injury.

BLACK-ROT.

Black-rot is one of the most serious diseases of cabbage in the field and is responsible for much of the loss from decay in storage. It is caused by a parasitic bacterium ^a which gains access to the young, growing plants through the roots or through marginal infection of the leaf. The bacteria then grow up from the roots or down from the point of infection of the leaf, through the fibro-vascular bundles, to the head. The black-rot organism itself, under storage conditions, seldom completes the destruction of the head, but cabbages affected by it are more liable to attack by soft-rot bacteria and by fungi, which develop rapidly under favorable conditions. The control of black-rot in the field, therefore, will greatly reduce the loss from decay in storage.

Upon cutting across the stem or through the leaf black-rot can be detected by the black ring in the woody part of the stem and by the blackening of the veins of the leaves.

^a *Bacterium campestris* (Pam.) Erw. Sm.

SOFT-ROT.

Soft-rot is due to a group of related species of bacteria rather than to one species. The bacteria gain access to the tissue of the leaves of the cabbage principally through wounds made by careless handling and by infection of the stem and leaves previously attacked by black-rot. Other crops, such as carrots and turnips, are subject to similar injury. The soft-rot bacteria as a class are marked by their ability to destroy plants very quickly under favorable temperature conditions. They seldom affect uninjured plants, but require a wound or other injury in order to gain a foothold.

LEAF-BLIGHT.

Leaf-blight is due to a fungus^a which attacks the plant at any stage of its growth but is more likely to develop on a plant subjected to unfavorable conditions. In the seed bed and in the field, leaf-blight is distinguished by the dark, mildewed spots it produces on the leaves. In warm storage houses and in the presence of sufficient moisture it spreads very rapidly over the leaves and causes considerable loss from decay. The fungus can not grow, however, at a temperature near freezing and in the absence of humidity.

STORAGE CONDITIONS NECESSARY FOR PREVENTING DECAY.

The most favorable results in the preservation of cabbage are secured only by the skillful regulation of the temperature and humidity through daily attention to the ventilation of the houses. Temperature and humidity are the most important factors to be considered in connection with cold storage. If the proper temperature, along with dry houses, could be kept, the organisms which cause the decay of cabbage would be held in check. In other words, the organisms would not develop if the temperature could be held at about one degree above the freezing point. Since it is impossible, owing to periods of warm weather in the winter, to maintain such a uniform temperature, humidity plays an important part. Decay would be much less in a house with high temperature and little humidity than in a house with high temperature and a relatively large amount of humidity.

Temperature and humidity must largely be controlled by a well-planned system of ventilation with outdoor air. When a long period of very cold weather makes it impossible to keep the temperature at a little above freezing, one or two stoves can be put in the house, which would also materially reduce the humidity. Moisture should not be allowed to condense on the cabbage, and not very

^a *Alternaria brassicæ* (Berk.) Sacc.

much on the walls and ceiling. Whenever moisture is condensed on the cabbage the house is in bad condition and should be dried at once, even if a stove must be put in and the temperature raised. After drying, the temperature could be reduced by admitting outside air through the doors. When stoves are put in houses care should be exercised that too much smoke does not escape inside, as this would probably injure the sale of the cabbage.

It is only in extreme cases that the proper condition of the house can not be maintained by ventilation with outside air. Cabbage is constantly giving off moisture unless frozen. If a house is kept closed, the relative humidity will increase until the air is saturated. Any reduction in temperature would then condense the moisture on the cabbage and the walls of the house. It is believed that the house should be opened every day except when warm or very damp. The house should be opened for ventilation during clear weather when the air is dry, and at a time of day when the temperature is near the freezing point. The temperature of the house would then be little changed, and the relative humidity inside would be reduced to that of the air outside.

In a storage house of a capacity of about 1,600 tons, in the State of New York, a system of ventilation has been installed which consists of pipes running through the building, through which the air in the house is drawn by a fan run by electric power. The pipes gradually decrease in size as they ramify through the building. It is claimed that by such a system the air can be changed in the whole building in twenty minutes. The owner makes it a practice to change the air once every twenty-four hours unless the temperature is very high and the air humid. His stock, when seen in midwinter, was in excellent condition. No decayed heads nor any moisture condensed on the cabbage were found.

CONSTRUCTION OF STORAGE HOUSES TO PREVENT DECAY.

Since the object in storing cabbage is to keep the house near the freezing point and as dry as possible, the construction of the house is important only in so far as it contributes to that end. It is probable that the best type of house is made of brick or stone, the walls being 18 to 24 inches in thickness. Thick walls are essential, since, being less affected by varying temperatures, they make it possible to keep the interior cool during a period of warm weather. The roof should be made of the usual sheathing and shingles. It would be preferable to have the sheathing run from the comb of the roof to the eaves, which would enable the water, if frost forms and melts on the inside, to run to the side of the building instead of dripping on the cabbage.

A house 100 feet in length should have at least four ventilators on the comb, which would permit outside air coming in from below to drive the warm, damp air out through the top. A building made of wood, with the walls two or three boards thick, though not as good as a stone house, has in many cases given good results.

METHODS OF STORING CABBAGE.

There are two common methods of storing cabbage—in bins and on shelves. Both have their advantages. Most storage men prefer to use bins, because in this way a larger tonnage of cabbage can be stored per cubic yard of space. Others, however, store on shelves, believing that the cabbage keeps better.

The aeration in bins is at best not good, and for that reason shelves, where the heads are only two or three deep, are preferable. When stored, the cabbage should be placed with the stem end upward, so that all water dripping from the ceiling or any moisture that may condense on the leaves will more readily run off.

CONCLUSIONS.

Soft-rot and leaf-blight are the immediate causes of the decay of cabbage in storage. The organisms causing these decays gain access to the tissues of the leaves through wounds made by careless handling and also by following up the fibro-vascular bundles which have been previously killed by black-rot.

Diseased or badly bruised cabbage should not be stored. The most important factors in the keeping of cabbage in storage are temperature and humidity. Water should not be allowed to accumulate in drops on the cabbage, and if it does immediate steps should be taken to dry the cabbage, either by admitting air from the outside or by the use of stoves inside. Stoves should not be used, however, if it is possible to obtain the same results by using cold, dry, outside air. Houses should be opened and ventilated every day except when the air is damp and warm. Cold weather, when the temperature is at about the freezing point, is best for ventilation.

The construction of houses, the methods of storing, etc., are important in so far as they contribute to the keeping of dry houses and the maintenance of a uniform temperature slightly above freezing.

Approved:

JAMES WILSON,
Secretary of Agriculture.

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